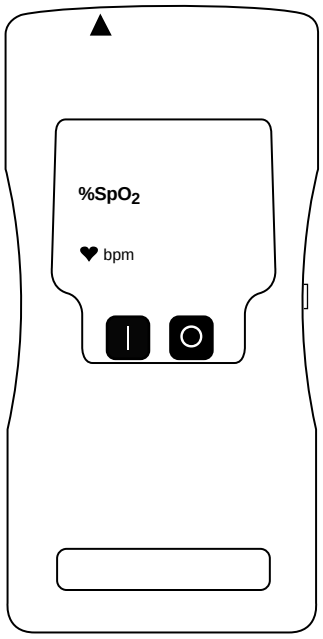
OXIMETER

OPERATION/SERVICE MANUAL



CATALOG NUMBER 1818E
VERSION 7, JUNE 2002
COPYRIGHT BCI, INC. - 2002

Oximeter Operation/Service Manual

Chapter 1: Introduction 1-1

About This Manual 1-1
Proprietary Notice 1-1
WARRANTY 1-1
Limited Warranty 1-1
Disclaimer of Warranties 1-2
Conditions of Warranty 1-2
Limitation of Remedies 1-2
Warranty Procedure 1-2
CE Notice 1-3
Symbol Definition 1-3
⚠ Warnings, Cautions, & Notes 1-4

Chapter 2: Oximeter Features 2-1

Intended Use 2-1
Features 2-1
Description of Controls & Features 2-2

Chapter 3: Theory of Operation 3-1

Chapter 4: Using the Oximeter 4-1

Unpack the Oximeter 4-1
Install the Batteries 4-1
Installing or Replacing the Batteries 4-2
Care and Handling of Sensor 4-3
Choose the Sensor 4-4
Attach the Sensor to the Patient 4-5
Clean or Disinfect the Sensors 4-5
Finger Sensor for Adult or Pediatric Finger 4-5
Attach the Sensor to the Oximeter 4-6
Measuring the Patient's % SpO_2 and Pulse Rate 4-6
Patient Numbers and Spot Check Data 4-8
Manually Incrementing the Patient Number 4-8
Clearing All Spot Check Data 4-8
Low Battery Indicator 4-8
Turning Off the Oximeter 4-9
Checking the Oximeter's Performance 4-9

Chapter 5: Printer 5-1

Description 5-1
Compatible Printers 5-2
What You'll Need for Printing 5-2
Setting Up the Oximeter and the Printer 5-3
Data Log Printouts 5-4
Spot Check Printouts 5-5
Collecting Spot Check Data 5-5
Manually Incrementing the Patient Number 5-5
Clearing All Spot Check Data 5-5
About the Oximeter's Batteries and Spot Check Data 5-5
Printing Spot Check Data 5-6

Chapter 6: Computer Interface 6-1

Description 6-1
Equipment Required 6-1
Computer Interface Instructions 6-1

Chapter 7: Operator's Maintenance 7-1

Batteries 7-1
Disposal of batteries and rechargeable batteries 7-1
Sensors 7-1
Reusable Sensors 7-1
Disposable Sensors 7-2
Cleaning the Oximeter's Surfaces 7-2
Long Term Storage 7-2

Chapter 8: Operator's Troubleshooting Chart 8-1

EMI Interference 8-3

Chapter 9: Optional Supplies & Accessories 9-1

Ordering Information: 9-1

Chapter 10: Specifications 10-1

Equipment Classification 10-1
Displays, Indicators, & Keys 10-1
SpO_2 10-1
Pulse Rate 10-2
Auxiliary Printer Output 10-2
Power Requirements 10-2
Battery Life 10-2
Dimensions 10-2
Environmental Specifications 10-2

Chapter 11: Service Maintenance & Repair 11-1

General Description 11-1
Oximeter On/Off Control 11-1
Power Supplies 11-2
Microprocessor Circuit 11-2
Reset Circuit 11-3
Memory and I/O Decoding 11-3
Addressable Latch 11-4
ON Key Decode 11-4
Synchronous Serial Port 11-4
Asynchronous Serial Port 11-5
Speaker Output 11-5
Analog Demultiplexer 11-5
A/D Converter 11-6
LED Drive 11-6
Signal Processing 11-6
Display Board 11-7
Signal Dictionary 11-7
Oximeter Board 11-7
Display Board 11-12
Test Equipment and Tools Required 11-12
Connecting a DC Power Supply 11-13
Voltage Test Points 11-13
Waveform Test Points 11-15

Appendix Appendix-1

Parts Lists Appendix-1
Assembly Drawings and Schematics Appendix-1

Chapter 1: Introduction

About This Manual

The operator's instructions provides installation, operation, and maintenance instructions. It is intended for health-care professionals trained in monitoring respiratory and cardiovascular activity.

The operator's instructions provides installation, operation, and maintenance instructions. It is intended for health-care professionals trained in monitoring respiratory and cardiovascular activity.

The service maintenance and repair section contains circuit descriptions, voltage and waveform test points, detailed parts lists, and circuit diagrams. It is intended for persons trained in service, maintenance, and repair of modern medical equipment. Thorough knowledge of this equipment's operation is required before attempting to repair this equipment.

Proprietary Notice

Information contained in this document is copyrighted by BCI, Inc. and may not be duplicated in full or part by any person without prior written approval of BCI, Inc. Its' purpose is to provide the user with adequately detailed documentation to efficiently install, operate, maintain and order spare parts for the device supplied. Every effort has been made to keep the information contained in this document current and accurate as of the date of publication or revision. However, no guarantee is given or implied that the document is error free or that it is accurate regarding any specification.

WARRANTY

Limited Warranty

Seller warrants to the original purchaser that the Product, not including accessories, shall be free from defects in materials and workmanship under normal use, if used in accordance with its labeling for two years from the date of shipment to the original purchaser.

Seller warrants to the original purchaser that the reusable oximeter sensors supplied as accessories, shall be free from defects in materials and workmanship under normal use, if used in accordance with its labeling for one year from the date of shipment to the original purchaser (USA).

Disclaimer of Warranties

THE FOREGOING EXPRESS WARRANTY, AS CONDITIONED AND LIMITED, IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Seller disclaims responsibility for the suitability of the Product for any particular medical treatment or for any medical complications resulting from the use of the Product. This disclaimer is dictated by the many elements which are beyond Seller's control, such as diagnosis of patient, conditions under which the Product may be used, handling of the Product after it leaves Seller's possession, execution of recommended instructions for use and others.

Conditions of Warranty

This warranty is void if the Product has been altered, misused, damaged by neglect or accident, not properly maintained or recharged, or repaired by persons not authorized by Seller. Misuse includes, but is not limited to, use not in compliance with the labeling or use with accessories not manufactured by Seller. This warranty does not cover normal wear and tear and maintenance items.

Limitation of Remedies

The original purchaser's exclusive remedy shall be, at Seller's sole option, the repair or replacement of the Product. **THIS IS THE EXCLUSIVE REMEDY. In no event will Seller's liability arising out of any cause whatsoever (whether such cause is based in contract, negligence, strict liability, tort or otherwise) exceed the price of the Product and in no event shall Seller be responsible for consequential, incidental or special damages of any kind or nature whatsoever, including but not limited to, lost business, revenues and profits.**

Warranty Procedure

To obtain warranty service in the USA, you must request a Customer Service Report (CSR) number from Technical Service. Reference the CSR number when returning your Product, freight and insurance prepaid, to: BCI, Inc., N7 W22025 Johnson Road, Waukesha, WI 53186-1856. Telephone: 1-800-558-2345. Facsimile: 262-542-3325. Seller will not be responsible for unauthorized returns or for loss or damage to the Product during the return shipment. The repaired or replaced Product will be shipped, freight prepaid, to Purchaser.

CE Notice

Marking by the symbol CE 0473 indicates compliance of this device to the Medical Device Directive 93/42/EEC.

Authorized Representative (as defined by the Medical Device Directive):

Graseby Medical Ltd.
Colonial Way, Watford, Herts,
UK, WD2 4LG

Phone: (44) 1923 246434
Fax: (44) 1923 240273

Symbol Definition

SYMBOL	DEFINITION
	Attention, consult accompanying documents.
	Type B equipment
REF	Catalog Number
SN	Serial number
	On
	Off
	Date of Manufacture
	Non AP Device
	Use by

⚠ Warnings, Cautions, & Notes

WARNING: Federal law (USA) restricts the use or sale of this device by, or on the order of, a physician.

WARNING: This device is not intended for continuous patient monitoring. This device is intended to measure the patient's % SpO_2 and pulse rate values. There are no audible or visible alarms.

WARNING: This device must be used in conjunction with clinical signs and symptoms. This device is only intended to be an adjunct in patient assessment.

WARNING: Do not use this device in the presence of flammable anesthetics.

WARNING: Do not use this device in the presence of magnetic resonance imaging (MR or MRI) equipment.

WARNING: Prolonged use or the patient's condition may require changing the sensor site periodically. Change sensor site and check skin integrity, circulatory status, and correct alignment at least every 4 hours.

WARNING: When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the instrument's user manual for full instructions. Accessory equipment connected to the monitor's data interface must be certified according to the respective IEC standards, i.e., IEC 950 for data processing equipment or IEC 601-1 for electromedical equipment. All combinations of equipment must be in compliance with IEC 601-1-1 systems requirements. Anyone connecting additional equipment to the signal input port or signal output port configures a medical system, and, therefore, is responsible that the system complies with the requirements of the system standard IEC 601-1-1.

WARNING: When attaching sensors with Microfoam®[1] tape, do not stretch the tape or attach the tape too tightly. Tape applied too tightly may cause inaccurate readings and blisters on the patient's skin (lack of skin respiration, not heat, causes the blisters).

CAUTION: Observe proper battery polarity (direction) when replacing batteries.

---

[1] Microfoam® is a registered trademark of the 3M Company.

CAUTION: Do not autoclave, ethylene oxide sterilize, or immerse the sensors in liquid.

CAUTION: This device is intended for use by persons trained in professional health care. The operator must be thoroughly familiar with the information in this manual before using the device. (Notice: This device is not approved for home use by a non-health care professional.)

CAUTION: Connect only the printer adapter specifically intended for use with this device (see *Optional Supplies and Accessories)*.

NOTE: Operation of this device may be adversely affected in the presence of strong electromagnetic sources, such as electrosurgery equipment.

NOTE: Operation of this device may be adversely affected in the presence of computed tomograph (CT) equipment.

NOTE: Use only SpO_2 sensors supplied with, or specifically intended for use with, this device.

NOTE: SpO_2 measurements may be adversely affected in the presence of high ambient light. Shield the sensor area (with a surgical towel, for example) if necessary.

NOTE: Dyes introduced into the bloodstream, such as methylene blue, indocyanine green, indigo carmine, and fluorescein, may adversely affect the accuracy of the SpO_2 reading.

NOTE: Any condition that restricts blood flow, such as use of a blood pressure cuff or extremes in systemic vascular resistance, may cause an inability to determine accurate pulse rate and SpO_2 readings.

NOTE: Remove fingernail polish or false fingernails before applying SpO_2 sensors. Fingernail polish or false fingernails may cause inaccurate SpO_2 readings.

NOTE: The presence of dyshemoglobins, such as carboxyhemoglobin (with CO-poisoning) or methemoglobin (with sulfonamide therapy) may adversely affect the accuracy of the SpO_2 measurement.

NOTE: Hazards arising from software errors have been minimized. Hazard analysis was performed to meet EN1441: 1997.

NOTE: Optical cross-talk can occur when two or more sensors are placed in close proximity. It can be eliminated by covering each site with opaque material.

Chapter 2: Oximeter Features

Intended Use

The oximeter provides fast, reliable SpO_2 and pulse rate measurements. It can be used in the hospital or clinical environment, and during emergency air or land transport. The oximeter will operate accurately over an ambient temperature range of 32 to 131° F (0 to 55° C). The oximeter works with all BCI, Inc. oximetry sensors providing SpO_2 and pulse rate on all patients from neonate to adult.

Features

- Provides fast, reliable SpO_2 and pulse rate measurements on any patient, from neonates to adults.
- Ideally suited for use in intensive care units, in outpatient clinics, in emergency rooms, or during emergency air or land transport.
- Portable and lightweight. Weighs only 9 ounces (255 grams) without the batteries.
- Ergonomically designed to fit comfortably in the palm of your hand.
- Uses three standard alkaline batteries (type LR 14) or three rechargeable (type KR27/50) NiCad "C" cell batteries.
- Battery life is approximately twenty-four (24) hours in continuous mode or eighty (80) hours in spot check mode.
- Bright, easy-to-read LED displays indicate SpO_2 and pulse rate measurements.
- An eight-segment LED bargraph indicates pulse strength.
- Automatically turns off after patient's finger is removed from the sensor.
- Low battery indicator lights when about two hours of battery use remains.
- Optionally connects to an external printer or computer, providing data log and spot check printouts of SpO_2 and pulse rate readings.
- Data log prints SpO_2 and pulse rate readings in real-time, once every five (5) seconds, on the optional printer or computer.
- Collects up to seventeen (17) hours of spot check data for up to ninety-nine (99) patients for printout later.

Description of Controls & Features

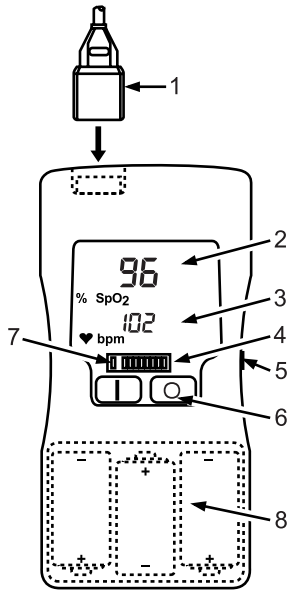


Figure 2-1: Oximeter Controls.

1. PATIENT CABLE/SENSOR
The sensor connects here. If you need the extra length of the patient cable, attach the sensor to the patient cable, then attach the patient cable to the oximeter's PATIENT CABLE/SENSOR connector.

2. % SpO_2 DISPLAY
The % SpO_2 value is shown here. Dashes (--) indicate the oximeter is unable to calculate the SpO_2 value.

3. PULSE RATE DISPLAY
The pulse rate value is shown in beats per minute (BPM). Dashes (---) indicate the oximeter is unable to calculate the pulse rate value. Flashing 255 indicates the pulse rate value is greater than 255.

4. PULSE STRENGTH BARGRAPH

The eight-segment bargraph "sweeps" with the patient's pulse beat, indicating pulse strength. The bargraph is logarithmically scaled to indicate a wide range of pulse strengths.

5. PRINTER OUTPUT

An optional printer connects here for printing data logs and spot check data. See *Printer* for more information on the printer output.

6. I & O KEYS

Press "I" to turn on the oximeter. Press "O" to turn off the oximeter.

While the oximeter is on, momentarily pressing the "I" key increments the patient number. While the oximeter is on, pressing and holding the "I" key for about six seconds clears all the spot check data and resets the patient number to P 1.

The oximeter turns off automatically two minutes after the sensor is removed from the patient or after the sensor is disconnected from the oximeter. This feature extends the battery use time.

7. LOW BATTERY INDICATOR

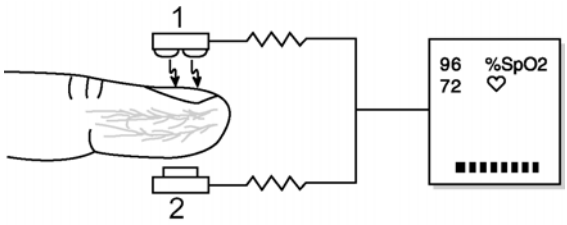
When about two hours of battery use time remains, the left-most bargraph segment lights. The oximeter will continue to operate normally until the batteries no longer have sufficient power to operate the oximeter. At that point, the oximeter automatically turns off.

8. BATTERIES AND ACCESS DOOR

The oximeter's three "C" cell batteries are accessed through this door on the back side of the oximeter. See *Installing or Replacing the Batteries* for details on installing or replacing the batteries.

Chapter 3: Theory of Operation

The oximeter determines SpO_2 and pulse rate by passing two wavelengths of light, one red and one infrared, through body tissue to a photodetector. During measurement, the signal strength resulting from each light source depends on the color and thickness of the body tissue, the sensor placement, the intensity of the light sources, and the absorption of the arterial and venous blood (including the time varying effects of the pulse) in the body tissues.



1. Low intensity red and infrared LED light sources
2. Detector

The oximeter processes these signals, separating the time invariant parameters (tissue thickness, skin color, light intensity, and venous blood) from the time variant parameters (arterial volume and SpO_2) to identify the pulse rate and calculate oxygen saturation. Oxygen saturation calculations can be performed because oxygen saturated blood predictably absorbs less red light than oxygen depleted blood.

Chapter 4: Using the Oximeter

Unpack the Oximeter

Carefully remove the oximeter and its accessories from the shipping carton. Save the packing materials in case the oximeter must be shipped or stored.

Compare the packing list with the supplies and equipment you received to make sure you have everything you'll need.

Install the Batteries

The oximeter uses three standard "C" cell batteries (type LR 14). You can use disposable alkaline batteries or rechargeable (type KR27/50) batteries.

If you use disposable batteries, be sure to dispose of them in compliance with your institution's guidelines and local ordinances.

If you use rechargeable batteries, it's best to have two sets of batteries on hand. That way, you can use one set of batteries in the oximeter while the other set of batteries is recharging.

NOTE: If you've collected spot check data for printing, make sure you print the spot check data before removing and replacing the oximeter's batteries. Removing the batteries erases spot check data from the oximeter's memory.

Installing or Replacing the Batteries

1. Turn over the oximeter so its back is facing you.
2. Push on the thumb grip and slide the door open.
3. If you're replacing the batteries, remove the old batteries from the battery compartment.

   If the old batteries are disposable, be sure to dispose of them in compliance with your institution's guidelines and local ordinances.

   If the old batteries are rechargeable, be sure to charge them right away so they'll be ready to use again as soon as possible.

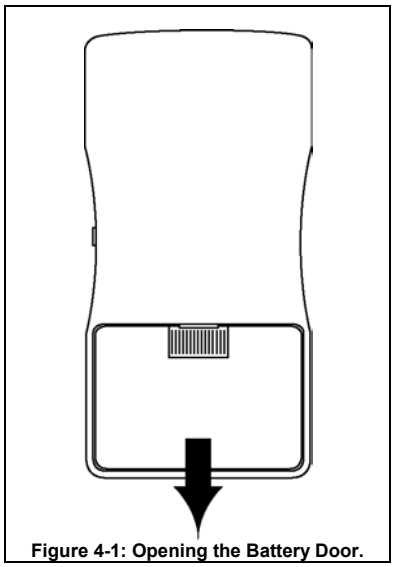


Figure 4-1: Opening the Battery Door.

4. Install three batteries in the oximeter battery compartment. Make sure the batteries are installed in the proper direction.

   NOTE: It is easiest to install the batteries in the sequence shown in Figure 4.2.

5. Slide the battery door closed, pushing firmly until it snaps into place.

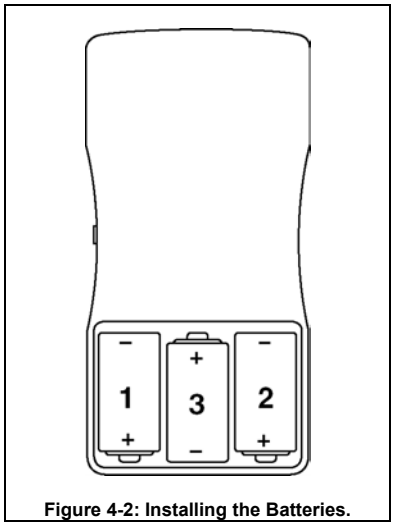


Figure 4-2: Installing the Batteries.

Care and Handling of Sensor

⚠ **WARNING! Misuse or improper handling of the sensor and cable could result in damaging the sensor. This may cause inaccurate readings.**

Hold the connector rather than the cable when connecting or disconnecting the finger sensor to the oximeter as shown in Figure 4.3.

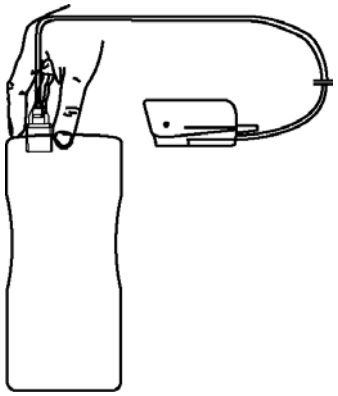


Figure 4.3: Disconnecting or Connecting the Finger Sensor.

Do not use excessive force, unnecessary twisting, or kinking when connecting, disconnecting, storing, or when using the sensor.

When placing the sensor on the patient, allow the cable to lay across the palm of the hand and parallel to the arm of the patient as shown in Figure 4.4.

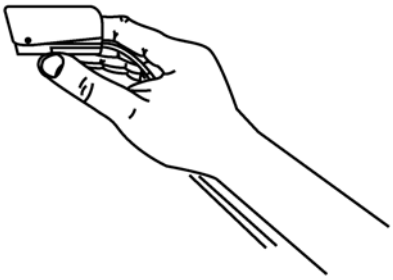


Figure 4.4: Positioning the Cable of the Finger Sensor.

Upon completion of patient monitoring, detach the sensor and loosely coil finger sensor cable. Do **not** wrap the finger sensor cable around the oximeter.

Choose the Sensor

Choose the appropriate sensor from the following chart. Refer to the sensor insert for application instructions.

Patient	Site	Description
Adult > 45 Kg	Finger	3044: Sensor, Adult
		3444 : Sensor Adult
	Finger or Toe	3043: Sensor, Universal "Y"
		1300: Sensor, Disp., Adult Finger
	Ear	3078: Sensor, Ear
Pediatric 15-45 Kg	Finger	3044: Sensor, Adult
		3444: Sensor Adult
	Finger or Toe	3043: Sensor, Universal "Y"
		1301: Sensor, Disp., Ped. Finger
	Ear	3078: Sensor, Ear
Infant 3-15 Kg	Hand or Foot	3043: Sensor, Universal "Y"
	Toe	3025: Sensor, Wrap, Infant
	Finger or Toe	1303: Sensor, Disp., Infant
Neonate < 3 Kg	Hand or Foot	1302: Sensor, Disp., Neonate
	Foot	3026: Sensor, Wrap, Neonate

Attach the Sensor to the Patient

⚠ **WARNING: Prolonged use or the patient's condition may require changing the sensor site periodically. Change sensor site and check skin integrity, circulatory status, and correct alignment at least every 4 hours.**

⚠ **WARNING: When attaching sensors with Microfoam® tape, do not stretch the tape or attach the tape too tightly. Tape applied too tightly may cause inaccurate readings and blisters on the patient's skin (lack of skin respiration, not heat, causes the blisters).**

Clean or Disinfect the Sensors

Clean or disinfect the reusable sensors before attaching a new patient.

⚠ **WARNING: Do not autoclave, ethylene oxide sterilize, or immerse the sensors in liquid.**

⚠ **CAUTION: Unplug the sensor from the monitor before cleaning or disinfecting.**

Clean the sensor with a soft cloth moistened in water or a mild soap solution. To disinfect the sensor, wipe the sensor with isopropyl alcohol.

Finger Sensor for Adult or Pediatric Finger

Attach the finger sensor to the patient as shown. Be sure to fully insert the patient's finger into the sensor. For patients with long fingernails, use the universal "Y" sensor.

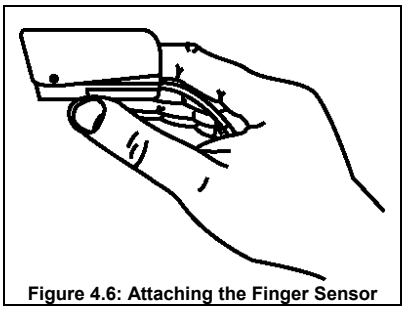


Figure 4.6: Attaching the Finger Sensor

Attach the Sensor to the Oximeter

- Attach the sensor connector to the oximeter's PATIENT CABLE/SENSOR connector.
- If you need the extra length of the patient cable, attach the sensor to the patient cable, then attach the patient cable to the oximeter's PATIENT CABLE/SENSOR connector.

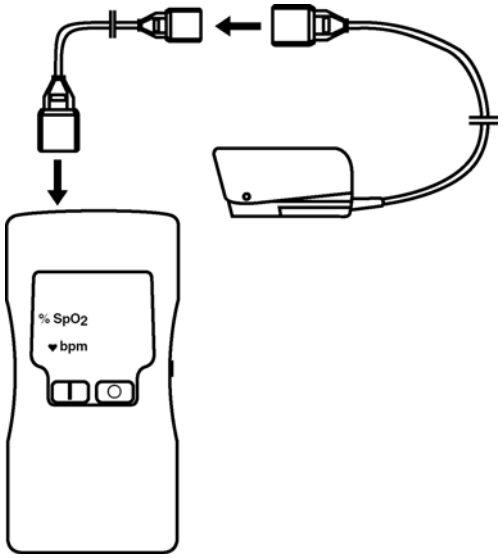


Figure 4-7: Attach the Sensor to the Oximeter

Measuring the Patient's % SpO_2 and Pulse Rate

To begin measuring the patient's SpO_2 and pulse rate, press the "⏻" key. When turned on, the oximeter goes through this power-up sequence:

- The pulse strength bargraph segments light one at a time.
- The oximeter's software revision is momentarily displayed.
- The patient number for spot check printouts is momentarily displayed. The format for the patient number display is "P" followed by the number. For example, P 14 means the patient number is 14.

After a few seconds the % SpO_2 value, pulse rate, and pulse strength bargraph should be shown. If not, see *Operator's Troubleshooting Chart* for help.

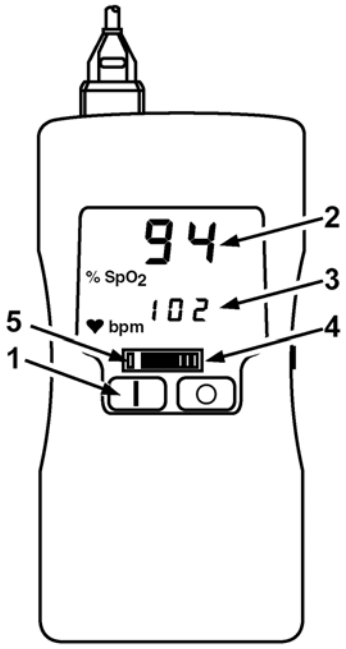


Figure 4-8: SpO_2, Pulse Rate and Pulse Strength Bargraph.

1. Press On
2. % SPO_2 value displayed
3. Pulse rate value displayed
4. pulse strength bargraph sweeping with patients pulse
5. low battery indicator

The SpO_2 display shows the patient's blood oxygen saturation, calculated as a percentage. The pulse rate display shows the patient's pulse rate in beats per minute (BPM). The pulse strength bargraph shows the patient's pulse strength; the bargraph is scaled logarithmically to indicate a wide range of pulse strengths.

Patient Numbers and Spot Check Data

Whenever the oximeter is on, it stores one SpO_2 and pulse rate reading every thirty (30) seconds. The stored readings are called *spot check* data. The oximeter remembers spot check data for up to ninety-nine (99) patients and seventeen (17) hours of run-time. The spot check data then can be printed at any time on the optional printer.

Spot check data is saved for each patient number. When you turn on the oximeter, the patient number is automatically incremented and displayed during the power-up sequence if valid spot check data was collected from the previous patient. When the patient number is incremented, then spot check data is saved for the new patient number. If no valid spot check data was collected from the previous patient, the patient number is displayed only and is not incremented. The oximeter remembers all the spot check data and all the patient numbers for up to ninety-nine (99) patients and seventeen (17) hours of run-time.

Manually Incrementing the Patient Number

Press the "↑" key while the oximeter is on to manually increment the patient number. The new patient number is momentarily displayed and spot check data for the new patient is automatically saved.

Clearing All Spot Check Data

Press and hold the "↑" key for about six seconds while the oximeter is on to clear all spot check data and reset the patient number to P 1. While you are holding the "↑" key, the message Clr flashes on the display to notify you that the spot check data for all patients is about to be cleared. When the spot check data is cleared, the display shows P 1.

See *Printer* for more information on printing spot check data.

Low Battery Indicator

When about two hours of battery use time remains, the left-most bargraph segment lights. The oximeter will continue to operate normally until the batteries no longer have sufficient power to operate the oximeter. At that point, the oximeter automatically turns off.

Turning Off the Oximeter

Press the "O" key to turn off the oximeter.

The oximeter turns off automatically two minutes after the sensor is removed from the patient or after the sensor is disconnected from the oximeter. This feature extends the battery use time.

NOTE: At power up, when the sensor is disconnected and patient data is stored, the oximeter will turn off automatically two minutes after the oximeter executes its print patient routine.

Checking the Oximeter's Performance

Pulse oximeters do not require user calibration. To check the function of the device, an optional Oximeter/ECG Patient Simulator is available as an accessory (BCI, Inc. Cat# 1606HH). The simulator attaches to the oximeter in place of the sensor or patient cable. It provides a known SpO_2 and pulse rate signal to the oximeter, allowing the oximeter's performance to be checked.

Follow the instructions included with the Oximeter/ECG Patient Simulator.

Chapter 5: Printer

Description

The oximeter has a built-in interface for an external printer. The oximeter can print data log and spot check printouts on the external printer.

- **Data Log:** In the data log mode, the patient's SpO_2 and pulse rate values are printed in real-time, once every five (5) seconds.

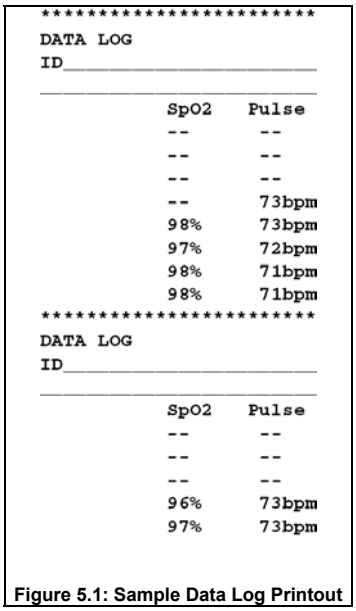


Figure 5.1: Sample Data Log Printout

- **Spot Check:** Whenever the oximeter is on, it stores one SpO_2 and pulse rate reading every thirty (30) seconds. The stored readings are called *spot check* data. The oximeter remembers spot check data for up to ninety-nine (99) patients and seventeen (17) hours of run-time. The spot check data then can be printed at any time on the optional printer.

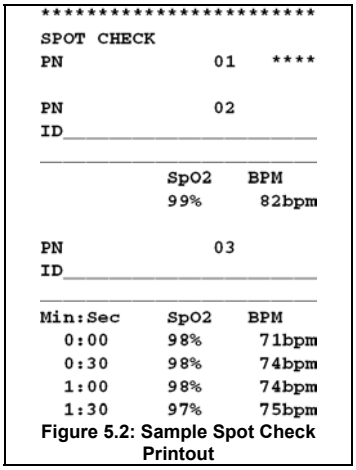


Figure 5.2: Sample Spot Check Printout

Compatible Printers

Printer requirements:

I/O Port:	Serial RS-232C
Data Type:	ASCII
Data Format:	600 baud, 1 start bit, 8 data bits, 1 stop bit, no parity
I/O Connector:	Standard DB-9

For information on printers and printer accessories, contact your authorized sales representative.

⚠ **WARNING: When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the instrument's user manual for full instructions. Accessory equipment connected to the monitor's data interface must be certified according to the respective IEC standards, i.e., IEC 950 for data processing equipment or IEC 601-1 for electromedical equipment. All combinations of equipment must be in compliance with IEC 601-1-1 systems requirements. Anyone connecting additional equipment to the signal input port or signal output port configures a medical system, and, therefore, is responsible that the system complies with the requirements of the system standard IEC 601-1-1.**

What You'll Need for Printing

You'll need these items to print data log or spot check printouts:

- Oximeter.
- Printer Adapter (see *Optional Supplies and Accessories* for ordering information).
- Compatible printer (purchased from one of the printer manufacturer's distributors).
- Accessories required for the printer, such as paper, power supply or charger, and so on (purchased from the printer manufacturer's distributor).

Setting Up the Oximeter and the Printer

Follow these steps to connect the printer adapter and the printer to the oximeter.

1. Refer to the printer's operation manual and make sure the printer's RS-232 data is properly setup.

CAUTION: Connect only the printer adapter specifically intended for use with this device (see *Optional Supplies and Accessories)*.

2. Connect the printer adapter's mini-phone jack to the oximeter's printer output.
3. Connect the printer adapter's DB-9 connector to the mating connector on the printer.
4. Connect the printer's power source to the printer as described in the printer's operation manual.
5. Make sure the printer has paper loaded and is ready to print as described in the printer's operation manual.

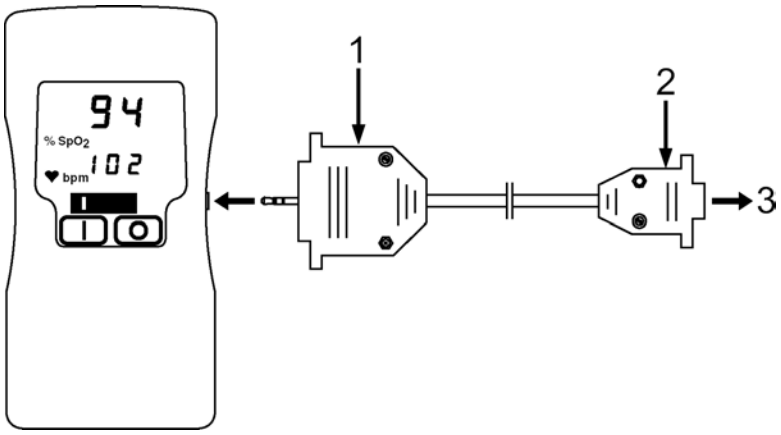


Figure 5.3: Setting Up the Oximeter and the Printer

1. connect to oximeter

2. printer adapter db-9 connector

3. to printer

Data Log Printouts

Follow these steps for data log printouts:

1. Set up the oximeter and the printer as previously described.
2. Connect the SpO_2 sensor to the patient and to the oximeter as previously described.
3. Turn on the printer.
4. Turn on the oximeter. The oximeter prints the SpO_2 and pulse rate measurements once every five (5) seconds as shown in the sample printout.
5. Pressing the "↑" key prints a new header and increments the patient number; real-time data is printed once every five (5) seconds again.
6. The oximeter continues to store spot check data, even when printing the data log.
7. Dashes indicate invalid or unavailable data (for example, the patient's finger was removed from the SpO_2 sensor).

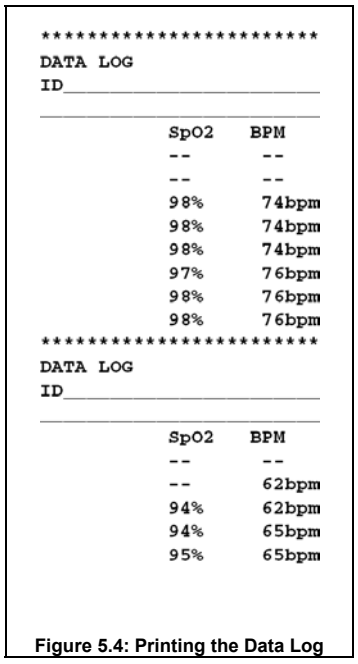


Figure 5.4: Printing the Data Log

8. If you disconnect the SpO_2 sensor while printing the data log, the data log printout continues (dashes are printed to indicate invalid or unavailable data). The data log continues to print until the oximeter is turned off or until the oximeter turns off automatically.

Spot Check Printouts

Collecting Spot Check Data

Whenever the oximeter is on, it stores one SpO_2 and pulse rate reading every thirty (30) seconds. The stored readings are called *spot check* data. The oximeter remembers spot check data for up to ninety-nine (99) patients and seventeen (17) hours of run-time. The spot check data then can be printed at any time on the optional printer.

Spot check data is saved for each patient number. When you turn on the oximeter, the patient number is automatically incremented and displayed during the power-up sequence if valid spot check data was collected from the previous patient. When the patient number is incremented, then spot check data is saved for the new patient number. If no valid spot check data was collected from the previous patient, the patient number is displayed only and is not incremented. The oximeter remembers all the spot check data and all the patient numbers for up to ninety-nine (99) patients and seventeen (17) hours of run-time.

Manually Incrementing the Patient Number

Press the "↑" key while the oximeter is on to manually increment the patient number. The new patient number is momentarily displayed and spot check data for the new patient is automatically saved.

Clearing All Spot Check Data

Press and hold the "↑" key for about six seconds while the oximeter is on to clear all spot check data and reset the patient number to P 1. While you are holding the "↑" key, the message Clr flashes on the display to notify you that the spot check data for all patients is about to be cleared. When the spot check data is cleared, the display shows P 1.

About the Oximeter's Batteries and Spot Check Data

NOTE: If you've collected spot check data for printing, make sure you print the spot check data before removing and replacing the oximeter's batteries. Removing the batteries erases spot check data from the oximeter's memory.

Printing Spot Check Data

1. Set up the oximeter and the printer as previously described.
2. Disconnect the SpO_2 sensor from the oximeter.
3. Turn on the printer.
4. Turn on the oximeter. The oximeter prints the spot check data for each patient, from patients 1-99, as shown in the sample printout.
5. If there is no spot check data at all, the message **** is printed.
6. The oximeter does not automatically turn itself off when printing spot check data.
7. If no valid data is collected for a patient number, VOID is printed.
8. If valid data is collected for a patient number for less than one minute, only the last measurement is printed.
9. If data is collected for a patient number for more than one minute, the relative time since the first measurement is shown for that patient.

```
************************
SPOT CHECK
PN              01    ****

PN              02
ID_____________________
_______________________
            SpO2    BPM
            98%      74bpm

PN              03
ID_____________________
_______________________
Min:Sec     SpO2    BPM
  0:00      94%      62bpm
  0:30      94%      65bpm
  1:00      95%      65bpm
  1:30      --       --
  2:00      --       --
```

Figure 5.5: Printing Spot Check Data

10. Dashes indicate invalid or unavailable data (for example, the patient's finger was removed from the SpO_2 sensor).
11. If you connect the SpO_2 sensor while printing spot check data, the spot check printout continues. If the SpO_2 sensor is connected to the oximeter after all spot check data for all patient numbers has been printed, a data log printout starts.
12. If you press the "↓" key while printing spot check data, the spot check printout stops and a data log printout starts. Pressing the "↓" key also increments the patient number, and spot check data is collected for the new patient number while the data log is printing.

Chapter 6: Computer Interface

Description

The oximeter can transfer real time and stored data to a PC. Information Data Log and Spot Checks will be displayed/saved to a file in the format as shown in the Printer section of this manual.

Equipment Required

1. Hand Held Oximeter
2. 3313 Printer Adapter Cable
3. 3339 PC Adapter Cable
4. Communication settings:

Baud rate	600
Data bits	8
Stop bits	1
Parity	none

Computer Interface Instructions

1. Disconnect the sensor from the oximeter for a Spot Check print out or connect the sensor for Data Log.

2. Connect the printer adapter cable (part #3313) to the unit via the side port connection.

3. Connect 9-pin connector of PC adapter cable (part #3339) to the printer adapter cable (part #3313).

4. Using the PC adapter cable (part #3339), connect the 9-pin connector of the PC adapter cable to the COM port on the PC as shown in figure 6.1.

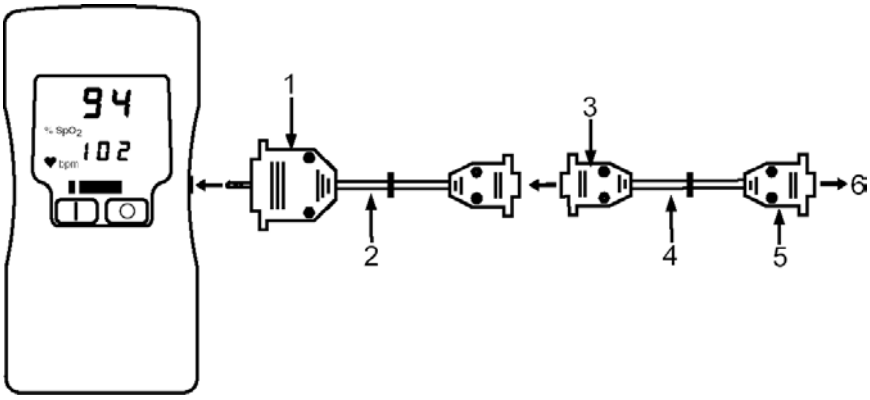


Figure 6.1: Connection from Oximeter to PC

1. connect to oximeter
2. cable catalog #3313
3. connect printer adapter db-9 connector to pc adapter db-9 connector
4. cable catalog #3339
5. pc adapter db-9 connector
6. to ibm compatible pc

⚠ **WARNING: When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the instrument's user manual for full instructions. Accessory equipment connected to the monitor's data interface must be certified according to the respective IEC standards, i.e., IEC 950 for data processing equipment or IEC 601-1 for electromedical equipment. All combinations of equipment must be in compliance with IEC 601-1-1 systems requirements. Anyone connecting additional equipment to the signal input port or signal output port configures a medical system, and, therefore, is responsible that the system complies with the requirements of the system standard IEC 601-1-1.**

Chapter 7: Operator's Maintenance

Batteries

When about two hours of battery use time remains, the left-most bargraph segment lights. The oximeter will continue to operate normally until the batteries no longer have sufficient power to operate the oximeter. At that point, the oximeter automatically turns off.

Replace weak or dead batteries with new disposable batteries or freshly charged NiCad batteries. See *Installing or Replacing the Batteries* for instructions.

Disposal of batteries and rechargeable batteries

Batteries and rechargeable batteries

- do not throw into fire - risk of explosion.
- do not force open - danger of corrosion.
- do not recharge normal batteries.

Batteries and rechargeable batteries must be treated as special waste:

- dispose of in accordance with local waste disposal regulations.

For information contact the local environmental protection offices or licensed waste disposal contractors.

Sensors

⚠ **WARNING: Prolonged use or the patient's condition may require changing the sensor site periodically. Change sensor site and check skin integrity, circulatory status, and correct alignment at least every 4 hours.**

⚠ **CAUTION: Do not autoclave, ethylene oxide sterilize, or immerse the sensors in liquid.**

Reusable Sensors

Clean the reusable sensor's surfaces with a soft cloth moistened in a mild soap solution. If disinfection is required, wipe the reusable sensor's surfaces with a soft cloth moistened in isopropyl alcohol. Do not allow liquid to enter any of the sensor's openings.

Disposable Sensors

Disposable sensors are for single-patient use only. Disposable sensors can be repositioned on the same patient as long as the correct SpO_2 and pulse rate values are shown after repositioning. Disposable sensors cannot be cleaned or repaired; discard them if they become soiled or no longer work.

Cleaning the Oximeter's Surfaces

⚠ **CAUTION: Do not autoclave, ethylene oxide sterilize, or immerse the oximeter in liquid.**

Clean the oximeter's surfaces with a soft cloth moistened in a mild soap solution. If disinfection is required, wipe the oximeter's surfaces with a soft cloth moistened in isopropyl alcohol. Do not allow any liquid to enter any of the oximeter's openings.

Long Term Storage

Remove the batteries from the oximeter before long term storage, or if the oximeter won't be used for 6 months or more. This protects the oximeter from damage due to batteries leaking acid.

Store the oximeter in its original shipping carton and packing materials to help protect the oximeter from damage during storage.

Chapter 8: Operator's Troubleshooting Chart

Problem	Possible Cause	Corrective Action
No pulse shown on the bargraph.	Patient cable or sensor is disconnected from the oximeter.	Check sensor connections to the patient cable and to the oximeter.
	Sensor is incorrectly positioned on the patient.	Reposition the sensor.
	Poor patient perfusion.	Reposition the sensor.
	Defective sensor or patient cable.	Try a new sensor or contact your authorized repair center for help.
Pulse rate is erratic, intermittent, or incorrect.	Sensor incorrectly positioned.	Reposition the sensor.
	Patient motion	
SpO_2 value is erratic, intermittent, or incorrect.	Poor patient perfusion.	Reposition the sensor
	Patient motion.	Patient must remain still to obtain an accurate measurement.
The oximeter doesn't turn on.	Batteries weak.	Replace the batteries.
	Batteries not installed or batteries incorrectly installed.	Ensure the batteries are installed correctly.

Problem	Possible Cause	Corrective Action
The oximeter turns off unexpectedly.	The oximeter turns itself off automatically two minutes after the sensor is removed from the patient or after the sensor is disconnected from the oximeter. This feature extends the battery use time.	None.
	Batteries are weak or dead.	Replace the batteries.
No printout on optional printer.	Printer power not connected, or printer power switch is off.	Connect the printer's power source and turn on the printer.
	Printer interface assembly not securely connected.	Push on both ends of the printer interface assembly to ensure all connections are tight.
	Printer interface malfunction.	Contact your authorized repair center for help.
E00	ROM Error	Contact BCI, Inc. Service
E01	RAM Error	Contact BCI, Inc. Service

EMI Interference

⚠ **CAUTION: This device has been tested and found to comply with the limits for medical devices to the IEC 601-1-2:1993, EN 60601-1-2:1994, Medical Device Directive 93/42/EEC. These limits are designed to provide reasonable protection against harmful interference in a typical medical installation. However, because of the proliferation of radio-frequency transmitting equipment and other sources of electrical noise in the heath-care and home environments (for example, cellular phone, mobile two-way radios, electrical appliances), it is possible that high levels of such interference due to close proximity or strength of a source, may result in disruption of performance of this device.**

The monitor is designed for use in environments in which the signal can be obscured by electromagnetic interference. During such interference, measurements may seem inappropriate or the monitor may not seem to operate correctly.

The monitor generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with these instructions, may cause harmful interference with other devices in the vicinity. Disruption may be evidenced by erratic readings. Cessation of operation, or other incorrect function. If this occurs, the site of use should be surveyed to determine the source of this disruption, and actions taken to eliminate the source:

- Turn equipment in the vicinity off and on to isolate the offending equipment.
- Reorient or relocate the other receiving device.
- Increase the separation between the interfering equipment and this equipment.

If assistance is required, contact BCI, Inc. Service Department or you local representative.

Chapter 9: Optional Supplies & Accessories

Cat. No	Description	Quantity
1300	Sensor, Oximetry, Disp., Adult Finger	10/box
1301	Sensor, Oximetry, Disp., Ped. Finger, 15-45 Kg	10/box
1302	Sensor, Oximetry, Disp., Neonate, < 3 Kg	10/box
1303	Sensor, Oximetry, Disp., Infant, 3-15 Kg	10/box
1606HH	Simulator & Cable, Oximeter, 5 ft.	each
1818E	Manual, Operation (Euro version)	each
3025	Sensor, Oximetry, Wrap, Infant, 3-15 Kg	each
3026	Sensor, Oximetry, Wrap, Neonate, < 3 Kg	each
3043	Sensor, Oximetry, Universal “Y”	each
3044	Sensor, Oximetry, Finger	each
3049	Strips, Adhesive	40/pkg
3078	Sensor, Oximetry, Ear	each
3134	Tape, Attachment, Neonatal	50/pkg
3135	Tape, Attachment, Infant	50/pkg
3136	Tape, Attachment, Neonatal	100/pkg
3137	Tape, Attachment, Infant	100/pkg
3138	Posey Wrap, Attachment, Universal "Y"	10/pkg.
3143	Attachment, OxiLink Small Finger	100/ctn
3144	Attachment, OxiLink Medium Finger	100/ctn
3145	Attachment, OxiLink Large Finger	100/ctn
3311	Cable, Patient	each
3313	Cable, Printer Interface	each
3314	Case, Carrying	each
3339	PC Adapter Cable	each
3444	Sensor, Oximetry, Finger, Comfort Clip	each

Ordering Information:

For ordering information, contact your local distributor or the BCI, Inc. customer service department.

BCI, Inc.
N7 W22025 Johnson Road
Waukesha, WI 53186 USA
Phone: 262 542 3100
Fax: 262 542 3325
Email Address: info@smiths-bci.com

Chapter 10: Specifications

Equipment Classification

Type of Protection Against Electric shock:	Internally Powered
Mode of operation:	Continuous
Degree of Protection Against ingress of Liquids:	IPX1, drip proof
Degree of Mobility:	Portable
Degree of Protection Against Electric Shock:	Type B
Safety Requirements:	EN60601-1; 1990

Displays, Indicators, & Keys

SpO_2:	LED numeric display, 0.43 inches (10.9 mm) high
Pulse Rate:	LED numeric display, 0.375 inches (9.5 mm) high
Pulse Strength:	Logarithmically scaled 8-segment LED bargraph
Keys:	I & O keys

SpO_2

Range:	0-99%
Accuracy:	±2% at 70-99% ±3% at 50-69%
Averaging:	8 pulse beat average
Display Response	The display is to functional saturation. The pulse strength bar graph is not proportional to pulse volume.
Display Update Rate	1 Hz (SpO_2); 60 Hz (pulse strength)
Calibration	Factory calibrated over range 50% to 100% SpO_2 using human blood samples to functional saturation. Test methods available upon request. No in-service calibration required.
Sensors	
Red	660nm, 2mW (typical)
Infrared	905nm, 2-2.4mW (typical)

Pulse Rate

Range:	30-254 BPM
Accuracy:	±2% at 30-254 BPM
Averaging:	8 second average
Display Update Rate	1 Hz

Auxiliary Printer Output

SpO_2 and pulse rate values can be output every five (5) seconds (data log). Data saved every thirty (30) seconds can be printed (spot-check).

Power Requirements

Uses three standard alkaline (type LR 14) or nickel-cadmium "C" cell batteries (type KR27/50).

Battery Life

Approximately 24 hours in continuous mode or 80 hours in spot check mode.

Dimensions

Width:	3.25 inches (82.6 mm)
Height:	6.3 inches (160 mm)
Depth:	1.25 inches (31.75 mm)
Weight:	9 ounces (255 grams) without the batteries

Environmental Specifications

Operating Temp.:	0-55° C (32-131° F)
Storage Temp.:	-34-70° C (-29-158° F)
Relative Humidity:	10-95% (storage), non-condensing
	15-95% (operating), non-condensing

Chapter 11: Service Maintenance & Repair

The service maintenance and repair section contains circuit descriptions, voltage and waveform test points, detailed parts lists, and circuit diagrams. It is intended for persons trained in service, maintenance, and repair of modern medical equipment. Thorough knowledge of this equipment's operation is required before attempting to repair this equipment.

General Description

The oximeter contains two circuit boards: the oximeter board and the display board. The oximeter board contains the power supplies, the on/off control logic, the microprocessor, and the data acquisition circuitry. The display board contains the ON/OFF keys, the 7-segment displays, and the led bargraph.

Oximeter On/Off Control

When the oximeter is off and the ON key is pressed, the following sequence occurs to turn on the oximeter:

- Pressing the ON key shorts U6-10 to ground , which causes flip-flop output U6-6 to go low.
- While U6-6 is low, Q8 turns on, which turns on Q7.
- While Q7 is on, the voltage at Q7-source is applied to the gate of P-channel FET Q5. This begins to turn on Q5, which provides V-BATT to the power supplies; however, Q5 is not fully on yet and consequently V-BATT is not yet at its highest possible voltage As the -5 volt power supply begins to operate, the voltage at Q7-source goes farther negative, turning on Q5 harder and eventually sending V-BATT to its highest possible voltage.
- When the battery voltage is low, Q13 acts to "jump start" the power on circuit. While the ON key is pressed, Q13 turns on and supplies V-BATT to the -5 volt supply, which quickly sends Q7-source and Q5-gate to a negative voltage to fully turn on Q5.

There are two ways the oximeter can be turned off: When the OFF key is pressed or when the microprocessor executes the HALT instruction. (The active low microprocessor output HALT is the signal SHUTDOWN.) U6D gates either of these conditions to turn off V-BATT. The following sequence occurs when either the OFF key is pressed or the signal SHUTDOWN is active:

- When either U6-12 (OFF key) or U6-13 (SHUTDOWN signal) goes low, U6-11 goes high.
- When U6-11 goes high, U6-3 to go low, sending U6-4 low, which causes flip-flop output U6-6 to go high. This turns off Q8, which turns off Q7, which turns off Q5; V-BATT is no longer provided to the regulators.
- Note that when flip-flop output U6-6 goes high, the other output of the flip-flop at U6-8 goes low. U6-8 (OFF-INT) is routed to the microprocessor's interrupt 1 line. This signals the microprocessor that the OFF key has been pressed and that the power will soon be off. The software performs "housekeeping" tasks before the power turns off.

Power Supplies

The unregulated battery voltage (V-BATT) is supplied to two "pulse skipper" regulators, U26 and U25. U26 supplies a regulated +5 volt output; U25 supplies a regulated -5 volt output. The +5 volt output (TP14) provides VCC, VDD, ANA+5, and FLTR+5. The -5 volt output (TP15) provides ANA-5 and FLTR-5.

The regulators generate electrical noise that might cause inaccurate measurements from the ADC. For this reason, the regulators are turned off for 2 msec out of 8 msec (during the data acquisition time). The signal QUIET turns off regulators U26 and U25 through diodes D2 and D1. (QUIET also turns off the LED displays at the same time it turns off U26 and U25.)

V-RAM supplies voltage to several system components whether the oximeter is on or off. Diode D5 provides V-RAM from the +5 volt supply while the oximeter is on or from V-BT while the oximeter is off. V-RAM powers RAM chip U23 (so U23 retains its trend memory for printouts) and V-RAM powers the power on/off circuit (so the power on/off circuit can respond to the ON key).

Microprocessor Circuit

A standard microprocessor kernel is formed by microprocessor U17, PROM U22, and RAM U23. Crystal X1, C59, and C60 form the oscillator circuit. The microprocessor's PHI output at U17-71 is one-half of X1's frequency.

Reset Circuit

U18, U19E, and U19D form a reset circuit. During power-up, U18-2 remains low until VCC reaches 4.5 volts, then U18-2 goes high. This holds the microprocessor and U20 in the reset state through U19E and U19D until VCC is regulating. If VCC begins to drop (VCC = 4.5 volts), U18-2 goes low. U18-2 is routed to the microprocessor's interrupt 2 line; U18-2 going low signals the microprocessor to perform "housekeeping" tasks and get ready to shut off. R502 and C501 delay the reset pulse from U18-2, allowing the microprocessor to execute the interrupt 2 routine before the microprocessor reset occurs.

Memory and I/O Decoding

Multiplexer U21B decodes A16, A17, and ME to allocate memory space. The following chart shows the memory address allocation:

Low Memory	High Memory	Enabled Device
00000H	0FFFFH	PROM U22
10000H	1FFFFH	RAM U23
20000H	2FFFFH	A/D U24 read and chip select strobe
30000H	3FFFFH	A/D U24 start conversion strobe

Multiplexer U21A decodes A6, A7, and IOE to allocate I/O space. The following chart shows the I/O address allocation:

Low I/O Addr.	High I/O Addr.	Signal or Enabled Device
00H	3FH	not used (64180 microprocessor internal I/O address space)
40H	7FH	DAC-LD load strobe to U15
80H	BFH	LATCH gate strobe to U20
C0H	FFH	DSP-LD strobe to display board U1

Addressable Latch

Addressable latch U20 decodes A0-A3 and provides 9 outputs for controlling the oximeter board's circuitry. The following chart shows the I/O addresses for LATCH, 80-8FH, and the functions for each I/O address:

I/O Address	Signal and Description
80H 81H	CAP-GND shunt inactive. CAP-GND shunt active.
82H 83H	RED-DRV (red LED) off. RED-DRV (red LED) on.
84H 85H	IR-DRV (infrared LED) off. IR-DRV (infrared LED) on.
86H 87H	RST-INT (integrator reset) off. INTGRAT (integrator) on. RST-INT (integrator reset) on. INTGRAT (integrator) off.
88H 89H	MUX-A = 0 MUX-A = 1
8AH 8BH	MUX-B = 0 MUX-B = 1
8CH 8DH	MUX-C = 0 MUX-C = 1
8EH 8FH	QUIET = off. QUIET = on.

ON Key Decode

The ON key is read by the microprocessor's DMA request line DREQ0 at U17-50. While the ON key is not being pressed, PON is high, which turns on Q14 and keeps U17-50 low. When the ON key is pressed then released, PON is pulled to ground then back to V-RAM; this turns off then on Q14. When Q14 is on, U17-50 responds to the low level and triggers DREQ0. The microprocessor recognizes DREQ0 as a pressing of the ON key.

Synchronous Serial Port

The microprocessor's synchronous serial port TXS/CKS is used to send data to the adjustable gain voltage to current converter U15 and to send data to the display driver chip U1. U15's data is latched with the I/O strobe DAC-LD; display driver chip U1's data is latched with the I/O strobe DSP-LD.

Asynchronous Serial Port

The microprocessor has two internal asynchronous serial ports: TXA0/RXA0 and TXA1/RXA1. TXA1 at U17-52 is jumpered at J3 to the signal TX. TX is buffered by U19A and routed to the serial port connector J2-ring. The RXA0 line at U17-49 is buffered by U19B and comes from the serial port connector J2-tip. J2-sleeve is connected to digital ground. J2 is the external printer connector.

Speaker Output

Microprocessor output A18 (TOUT) is configured as a timer output and controls the tone of the optional pulse beep speaker.

Analog Demultiplexer

Analog demultiplexer U13 routes one of eight possible analog inputs to a single output. The signals MUX-A, MUX-B, and MUX-C from addressable latch U20 control which input gets routed to U13's output as shown in the following chart: (For the addresses of these signals, see earlier in this section *Addressable Latch*.)

Signal	MUX-C	MUX-B	MUX-A	U13 Input
A-Ground	0	0	0	X0
V-REF	0	0	1	X1
V-A	0	1	0	X2
V-BATT	0	1	1	X3
PRB-DET	1	0	0	X4
not used	1	0	1	X5
not used	1	1	0	X6
not used	1	1	1	X7

The output of U13 is buffered by U14B then amplified (A_V = -5) by U14A. The output of U14A (SIGNAL at TP9) is routed to the input of the ADC.

A/D Converter

A/D converter (ADC) U24 is configured as a 12-bit ADC. The ADC's input voltage comes from SIGNAL at TP9. The ADC's reference voltage output, 3.000 VDC, is used by the analog circuitry. The following sequence describes an ADC conversion cycle:

- Write to memory address 30000H to pulse low U24-27. This pulses the ADC's /CONVST (start conversion) input to begin the conversion cycle.
- Wait 10 µsec, then read memory address 20000H for the low order 8 bits of the 12-bit conversion. Read memory address 20001H for the high order 4 bits of the 12-bit conversion.

LED Drive

The red LED drive circuit is formed by Q11, Q1, Q3, and their associated discrete components. When the signal RED-DRV is pulsed high, Q11 turns on, which turns on Q1 and Q3. While Q1 is on, current flows from ANA+5V through Q1, through J1-3 to the anode of the red LED, through J1-2 from the cathode of the red LED, through Q3, through R13, to ground. Q3 provides a constant current sink by D7 at Q3-base and R13 at Q3-emitter.

The infrared (IR) LED drive circuit is formed by Q10, Q4, Q2, and their associated discrete components. When the signal IR-DRV is pulsed high, Q10 turns on, which turns on Q4 and Q2. While Q4 is on, current flows from ANA+5V through Q4, through J1-2 to the anode of the IR LED, through J1-3 from the cathode of the IR LED, through Q2, through R12, to ground. Q2 provides a constant current sink by D6 at Q2-base and R12 at Q2-emitter.

Signal Processing

The differential transconductance amplifier formed by U5A and U4 converts the photodetector's current output to a voltage at TP7 (V-AMB). Unity gain amplifier U3A offsets the signal at TP7 so the signal baseline is at 3 VDC. This allows a wider signal range for the negative-going pulses at TP7.

V-AMB is passed through blocking capacitor C42 to remove the signal's DC component, then the signal is buffered by U3B. The output of U3B is routed to adjustable gain, voltage to current converter U15. The microprocessor determines the appropriate gain for the signal, then loads this value into U15 with the signals TXS, CKS, and DAC-LD. The output of U15 is routed to current to voltage converter U16. (Note that U12B "zeros" the output of U16 for the time while no signal of interest is present at U16; this prevents U16 from saturating.)

U16's output is integrated and filtered by U12A, and is routed to amplifier U14A. U13 passes V-REF to TP8 and to the input of U14A to sum V-REF with the signal from U12A. The output of U14A (SIGNAL at TP9) is routed to the ADC for measurement.

Display Board

The display board contains the ON and OFF keys, the LED display driver chip, the 7-segment displays, and the LED Bargraph. The display board is interfaced to the oximeter board through an 8-conductor flexible strip cable.

While pressed, the ON and OFF keys short to ground. The oximeter responds to these key presses as described earlier in *Oximeter On/Off Control.*

The display driver chip U1 receives synchronous data from the microprocessor's TXS and CKS lines. The data is loaded with the I/O strobe DSP-LD.

U1 generates electrical noise that might cause inaccurate measurements from the ADC. For this reason, U1 is turned off for 2 msec out of 8 msec (during the data acquisition time). The signal QUIET turns off U1.

U1 controls the 7-segment displays and the LED bargraph according to the data it receives from the TXS serial channel. The brightness of the displays is controlled by the I-SET input at U1-18. For the LED bargraph, DS2, and DS-3, the brightness is controlled by R1. For DS-4, DS-5, and DS-6, the brightness is adjusted down by allowing current to flow through R3 and D1, D2, or D3.

Signal Dictionary

This section lists in alphabetical order the signal names used on the schematics. The signal's origin, destination, and purpose are described.

Oximeter Board

A0-A17	A0 through A17 are the microprocessor's address lines. A0-A17 are used to address the RAM, PROM, and I/O ports.
A18	Microprocessor output A18 (TOUT) is configured as a timer output and controls the tone of the optional pulse beep speaker.
ANA+5	The +5 volt power supply VCC is filtered by L1, C20, and C21 to produce ANA+5. ANA+5 powers the analog circuitry.
ANA-5	The -5 volt power supply is filtered by L3, C22, and C19 to produce ANA-5. ANA-5 powers the analog circuitry.

BATT-OFF	BATT-OFF originates at Q7-drain and is routed to Q5-gate. When Q7 is on, Q7-drain is low, which turns on Q5. When Q5 is on, V-BATT is provided to the +5 and -5 volt regulators.
CAP-GND	CAP-GND originates at addressable latch U20 and is routed to analog switch U11. When CAP-GND is on, the blocking capacitor C42 is shunted to ground; this action sets the baseline of V-AMB to ground before data acquisition.
CKS	CKS is the microprocessor's high-speed, synchronous serial output clock signal. CKS is routed to two serial clocked devices: the display board's driver U1 and the adjustable gain, voltage to current converter U15.
D0-D7	D0 through D7 are the microprocessor's data lines. The data lines are routed to RAM U23, PROM U22, and ADC U24.
DAC-LD	DAC-LD originates at decoder U21A. DAC-LD is routed to the serial clocked, adjustable gain, voltage to current converter U15. When DAC-LD is strobed, U15 loads data from TXS.
DSP-LD	DSP-LD originates at decoder U21A. DSP-LD is routed to the display board's driver U1. When DSP-LD is strobed, U1 (on the display board) loads data from TXS.
FLTR+5	The ANA+5 power supply is filtered by R1, C14, and C13 to produce FLTR+5. The FLTR+5 supply powers the photodetector's first stage amplifier.
FLTR-5	The ANA-5 power supply is filtered by R2, C15, and C16 to produce FLTR-5. The FLTR-5 supply powers the photodetector's first stage amplifier.
INTGRAT	INTGRAT originates at addressable latch U20 and is routed to analog switch U11. When INTGRAT is on, the signal at TP6 is integrated by U12A. When INTGRAT is off, the signal at TP6 is not allowed to pass to the integrator, and the integrator is reset by the action of RST-INT.
IR-DRV	IR-DRV originates at addressable latch U20 and is routed to the infrared LED drive circuit at Q10. When IR-DRV is pulsed on, the sensor's infrared LED is pulsed on.
LATCH	LATCH originates at decoder U21 and is routed to addressable latch U20. LATCH loads and latches the state of A0 for the Q output specified by A1 through A3.
ME	ME is the microprocessor's memory enable output. ME is routed to decoder U21B to enable memory decoding.

MUX-A	MUX-A originates at addressable latch U20 and is routed to analog demultiplexer U13's "A" input.
MUX-B	MUX-B originates at addressable latch U20 and is routed to analog demultiplexer U13's "B" input.
MUX-C	MUX-C originates at addressable latch U20 and is routed to analog demultiplexer U13's "C" input.
OFF	OFF originates at the display board's OFF key and is routed to the on/off control circuit. OFF is pulled to V-RAM through R27 and R26. While the OFF key is pressed, the signal OFF goes low. This turns off Q8, Q7, and Q5, which turns off the voltage to the regulator chips. OFF-INT goes low also.
OFF-INT	OFF-INT originates at the on/off flip-flop formed by U6C and U6B and is routed to the microprocessor's INT1 (interrupt 1) input. When the OFF key is pressed, OFF-INT goes low, generating an interrupt request at the microprocessor. The microprocessor responds to the interrupt by performing several "housekeeping" tasks before the oximeter turns off.
OFFS-NULL	OFFS-NULL originates at addressable latch U20 and is routed to analog switch U11. When OFFS-NULL is on (between data acquisition periods), the output of U16 is zeroed by U12. This prevents U16 from saturating during data acquisition.
ON	ON originates at the display board's ON key and is routed to the on/off control circuit. ON is pulled to V-RAM through R24 and R25. While the ON key is pressed, the signal ON goes low. This turns on Q8, Q7, and Q5, which turns on the voltage to the regulator chips.
PON	PON is derived from the ON signal. PON is inverted by Q14; the resulting signal is read by the microprocessor's DMA request line DREQ0 at U17-50. When the ON key is pressed then released, PON is pulled to ground then back to V-RAM; this turns off then on Q14. When Q14 is on, U17-50 responds to the low level and triggers DREQ0. The microprocessor recognizes DREQ0 as a pressing of the ON key.
PRB-DET	PRB-DET originates at the sensor connector and is routed to analog demultiplexer U13. The sensor's connector has pins 1 and 6 shorted, so pin 1 (PRB-DET) is pulled to ground while the sensor is connected. The voltage level at PRB-DET is read by the ADC to determine if the sensor is connected (0 VDC) or if the sensor is not connected (about 590 mVDC at U13-1).

QUIET	QUIET originates at addressable latch U20; QUIET is routed to the +5 and -5 volt power supplies and the display board's driver U1. QUIET turns off the power supplies and the displays during the data acquisition time (2 msec out of 8 msec total).
RAM	RAM originates at Q9-drain and is routed to U23's /CS1 (chip select) input. While the reset signal to the microprocessor is active, Q9 is off and RAM is pulled to V-RAM through R45; this disables read and write cycles to RAM U23. While the reset signal to the microprocessor is not active, Q9 is on; this pulls RAM to ground and enables read and write cycles to RAM U23.
RD	RD is the microprocessor's read signal. It is routed to PROM U22 and RAM U23.
RED-DRV	RED-DRV originates at addressable latch U20 and is routed to the red LED drive circuit at Q11. When RED-DRV is pulsed on, the sensor's red LED is pulsed on.
RST-INT	RST-INT originates at addressable latch U20 and is routed to analog switch U11. When RST-INT is on, the integrator output at U12A is reset. When RST-INT is off, the signal at TP6 is integrated by U12A.
RXA0	RXA0 originates at serial port connector J2 and is routed to the microprocessor's RXA0 input. RXA0 is the received data from the external printer port connector.
SHUTDOWN	SHUTDOWN originates at the microprocessor's halt output U17-61. SHUTDOWN is gated at U6D to turn off the power supply as previously described. The microprocessor executes the halt instruction to automatically turn off the oximeter.
SIGNAL	SIGNAL originates at TP9 and is routed to ADC U24's VIN input. Depending on the state of the analog demultiplexer U13, SIGNAL represents either GROUND, V-REF, V-BATT, PRB-DET, or the sensor signal.
TX	TX is jumper-selectable for the microprocessor's asynchronous serial port TXA0 or TXA1. The current configuration routes TXA1 (U17-52) to TX. TX is buffered and routed to the serial port connect J2. TX is the transmitted data to the external printer port connector.

TXS	TXS is the microprocessor's high-speed, synchronous serial output transmitted data signal. TXS is routed to two serial clocked devices: the display board's driver U1 and the adjustable gain, voltage to current converter U15.
V-AMB	V-AMB (TP7) originates at the output of amplifier U4. V-AMB is routed to blocking capacitor C42. The DC level of V-AMB represents the fixed offset (3.000 VDC) minus the amount of light sensed by the photodetector. V-AMB is the same signal as V-A; V-A is routed to analog demultiplexer U13. V-A is measured by the ADC then tested to determine if U4 is saturated.
V-BATT	V-BATT originates at Q5-source. V-BATT supplies the battery voltage through Q5 to the +5 and -5 volt regulators while Q5 is fully on.
V-BT	V-BT is the battery voltage after passing through fuse F1. V-BT supplies V-RAM through D5 while the oximeter is off; V-BT supplies V-BATT through Q5 while the oximeter is on; V-BT provides the positive bias for the optional pulse beep speaker.
V-RAM	V-RAM comes from the V-BT supply while the oximeter is off, or from the VCC supply while the oximeter is on. Back-to-back Shottky diode D5 controls which supply provides V-RAM. The V-RAM supply powers the CMOS RAM chip and the oximeter on/off control circuit.
V-REF	V-REF originates at the REFOUT pin of ADC U24 and is routed to two circuits: the fixed-offset driver formed by U3A and the analog demultiplexer U13.
VCC	VCC is the regulated +5 VDC supply generated by +5 volt power supply regulator chip U26 and its discrete components.
VDD	Same as VCC.
VSS	Digital ground.
WR	WR is the microprocessor's write signal. It is routed to PROM U22 and RAM U23.

Display Board

CKS	Same as oximeter board CKS.
DIG1-DIG5	DIG1 through DIG5 originate at display driver U1 and are routed to the common cathode pins of the seven-segment LED displays DS2 through DS6. DIG1 is pulsed low to turn on the segments at DS2 represented by Sa-Sg. This is repeated for DIG2 and DS3 through DIG5 and DS6; then DIG1 is pulsed again. The entire cycle is controlled by display driver U1 as it receives data from the microprocessor's CKS signal.
DSP+	DSP+ originates at the output of the +5 volt power supply regulator chip U26. DSP+ powers the display driver U1.
DSP-LD	Same as oximeter board DSP-LD.
OFF	Same as oximeter board OFF.
ON	Same as oximeter board ON.
QUIET	Same as oximeter board QUIET.
Sa-Sg	Sa-Sg originate at display driver U1 and are routed to the seven-segment displays and the led Bargraph. The state of Sa through Sg determine which display or bargraph segments light when the corresponding DIG signal is strobed.
TXS	Same as oximeter board TXS.

Test Equipment and Tools Required

To diagnose and repair the full extent of possible malfunctions on the oximeter and display board, you'll need the following test equipment and tools:

- DMM volts/ohms/amps, with 10 MΩ input impedance or greater
- Oscilloscope, 50 MHz, with 10 MΩ input impedance or greater
- Variable output DC power supply, 0-5 VDC at 200 mA or greater
- Small Phillips screwdriver
- Small flat blade screwdriver
- Needle nose pliers
- Diagonal cutters
- Clip leads
- Low-power microscope or magnifying glass
- Soldering iron and solder
- Solder wick or solder remover

Connecting a DC Power Supply

To verify some of the voltage measurements that follow, you'll need to connect a variable output DC power supply in place of the three "C" cell batteries. You must be careful to observe the polarity of P1 when doing this. Follow these steps to connect a DC power supply in place of the "C" cell batteries:

⚠ **CAUTION:** Be sure to observe the polarity of the battery connections. Failure to observe the polarity may cause fuse F1 to blow.

1. Remove the three "C" cell batteries.
2. Connect the DC power supply's "+" output to P1-1.
3. Connect the DC power supply's "-" or "ground" output to P1-2.

Voltage Test Points

Unless otherwise noted, all voltages are measured with respect to ground at P1-2.

Location	Condition	Nominal and Range
TP14	Oximeter on.	5 VDC, ± 0.1 VDC
ANA+5	Same as TP14.	Same as TP14.
FLTR+5	Same as TP14.	Same as TP14.
TP15	Oximeter on.	-4.8 VDC to -6.2 VDC
ANA-5	Same as TP15.	Same as TP15.
FLTR-5	Same as TP15.	Same as TP15.
V-REF	Oximeter on.	3.000 VDC
V-RAM	Oximeter on. Oximeter off.	TP15 minus 0.4 VDC. P1-1 minus 0.4 VDC.
RAM	Oximeter on. Oximeter off.	Same as V-RAM. Near 0 VDC.
U18-2	Oximeter on. VCC at 4.5 VDC or less.	Same as TP14. Near 0 VDC.
TP19	No sensor connected.	3 VDC, ± 0.1 VDC
U17-71	Oximeter on.	3.072 MHz, 50% duty cycle.
Low battery LED.	When battery voltage drops from 3.8 VDC to 3.0 VDC.	Low battery LED first turns on at 3.0 VDC, ±0.2 VDC.

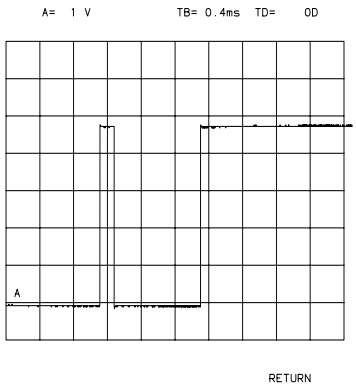
Location	Condition	Nominal and Range
Low battery shut off.	Oximeter on, battery voltage slowly dropping from 3.8 VDC.	Oximeter shuts off when battery voltage drops to 2.6 VDC, ± 0.2 VDC.
Automatic shut off.	Turn on oximeter and place finger in sensor. Remove finger from sensor. Remove sensor from oximeter. Turn on oximeter.	Oximeter should turn off 2 minutes (± 5 seconds) after finger is removed from sensor. Oximeter should turn off in 2 minutes (± 5 seconds).
Current draw through P1-1 (total battery current).	Oximeter on, sensor attached to oximeter, no finger in the sensor, with battery voltage at 3.5 VDC, ±0.2 VDC.	110 mA, ± 15 mA

Waveform Test Points

The following oscilloscope screens show typical waveforms from the sensor detector's amplifier and data acquisition circuits. Unless otherwise noted:

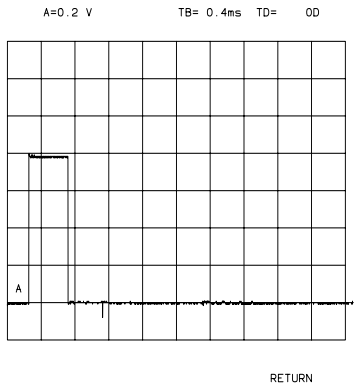
- The waveforms are measured with respect to ground at P1-2.
- The oscilloscope is triggered on TP11, falling edge.
- The waveforms are measured with the finger sensor attached to the oximeter, but no finger inserted in the sensor

TP11:



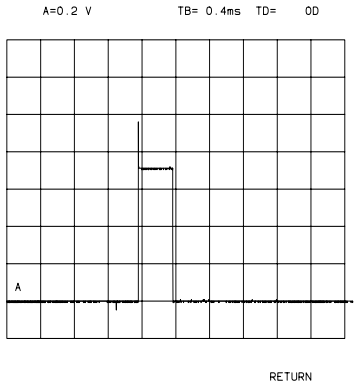
BASELINE = 0V

TP20:



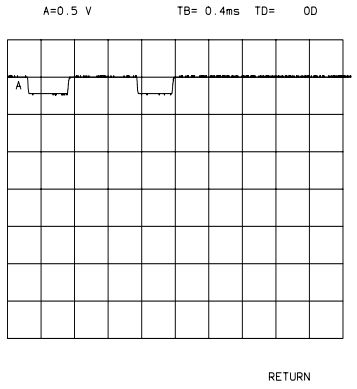
BASELINE = 0V

TP21:



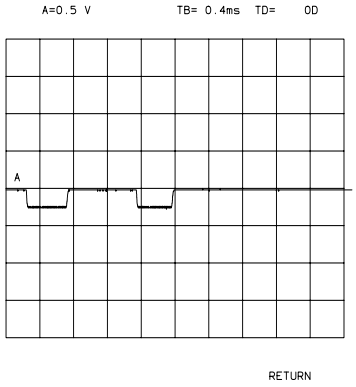
BASELINE = 0V

TP7:



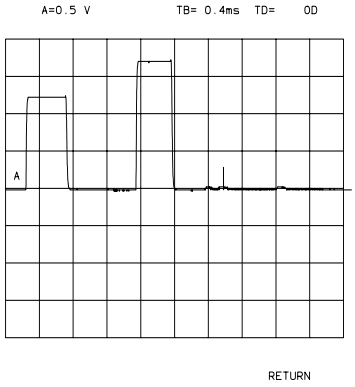
BASELINE = 0V

TP18:



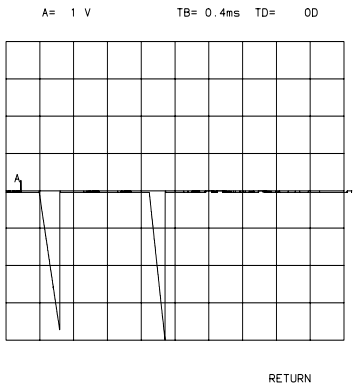
BASELINE = 0V

TP6:



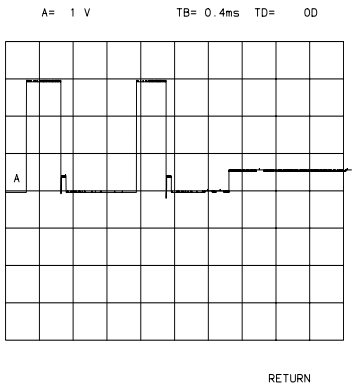
BASELINE = 0V

TP17:



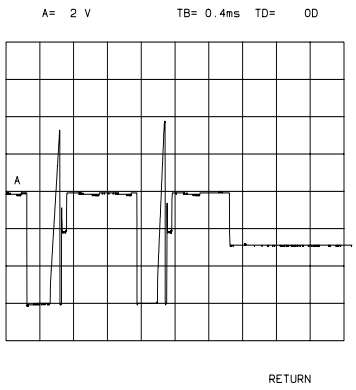
BASELINE = 0V

TP8:



BASELINE = 0V

TP9:



BASELINE = 0V

Appendix

Assembly Drawings, Schematics & Parts Lists

Number	Description	Page
71000A1	F/ASM OXIMETER BOM	A-1
71002B1	PWB ASM MAIN PARTS LIST	A-2
71004B1	PWB ASM DISPLAY PARTS LIST	A-5
71000A1	F/ASM OXIMETER	A-6
71002B1	PWB ASM MAIN	A-7
71004B1	PWB ASM DISPLAY	A-9
71000S	SYSTEM SCHEMATIC	A-10
71002S1	MAIN BOARD SCHEMATIC	A-11
71004S	DISPLAY BOARD SCHEMATIC	A-16

Smiths Medical – a part of Smiths Group plc

CE 0473

Authorized Representative (as defined by the Medical Device Directive):

Graseby Medical Ltd.
Colonial Way, Watford, Herts,
UK, WD2 4LG

Phone: (44) 1923 246434
Fax: (44) 1923 240273